Inducing Presyncope in Men: A Comparison of Two Stimuli

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NASA has identified cardiovascular deconditioning as a serious biomedical problem associated with long-duration exposure to microgravity in space. High priority has been given to the development of countermeasures for this disorder and the resulting orthostatic intolerance experienced by crewmembers upon their return to the unit gravity norm of Earth. Microgravity leads to cardiovascular deconditioning in humans, which is manifested by postflight reduction of orthostatic tolerance and upright exercise capacity. Recent studies tested the effects on orthostasis produced by combining 60 degree head-up tilt (HUT) with lower body negative pressure (LBNP) (see first figure). The procedure for this test consisted of HUT for 20 minutes, then added –20 millimeters mercury (mmHg) negative pressure for 10 minutes, and progressed to –40 mmHg for 10 minutes. The results showed that this combined stimulus test produced presyncope symptoms in 84% of the test subjects (N = 40).

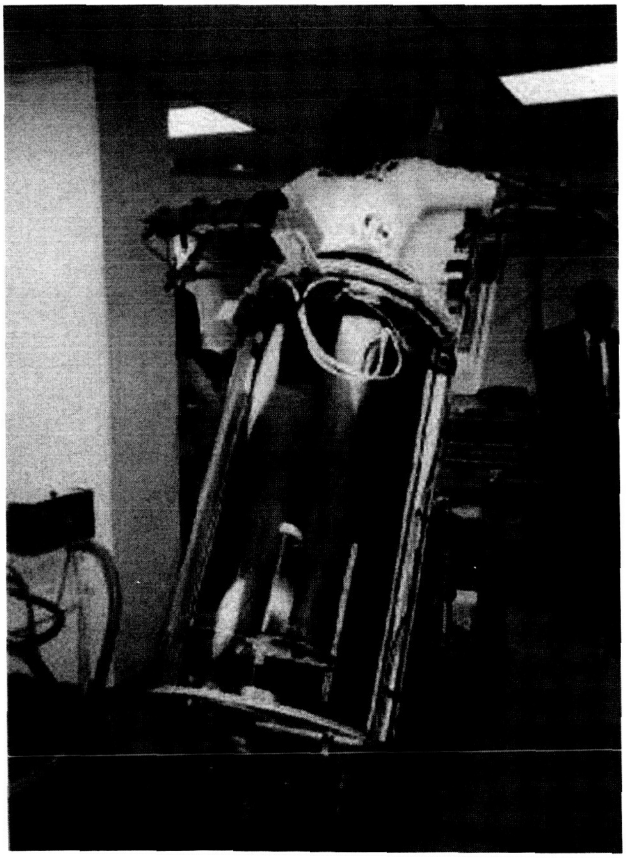

Fig. 1. Subject during 60° HUT and LBNP.

The primary purpose of the present study was to directly compare two tests of orthostatic tolerance in normal adult men. The first was a LBNP test, and the second was a combined test of HUT and LBNP. In order to test countermeasures for postflight orthostatic intolerance, the investigators must understand the nature of physiological responses to a gravitational stress. They believe that each individual will produce a unique physiological response pattern that will reliably describe his/her own symptom levels. The investigators wanted to determine which of these types of tolerance test were best suited for subsequently evaluating treatments or countermeasures that will be used to help future astronauts adapt more readily to microgravity, as well as to facilitate readaptation to Earth.

The specific hypotheses were: (1) The HUT + LBNP will induce presyncopal symptoms at lower levels of negative pressure than the supine LBNP test will, and (2) physiological measures will show distinct changes when test conditions change—that is, at the initiation of each step in the LBNP, at the initiation of HUT + LBNP, and at the point when presyncopal symptoms occurred (termination of the test). These data could be used to objectively characterize symptom levels experienced by individuals and individual differences in tolerance to these tests.

Results on a one-tailed t-test showed that subjects could tolerate the supine LBNP significantly longer than the combined HUT + LBNP ($p < 0.0004$). All physiological data indicated that the combined HUT + LBNP stimulus produced higher stress levels throughout the test than were observed for the supine LBNP. The second figure shows the heart rate data of subjects during both tests under conditions of supine

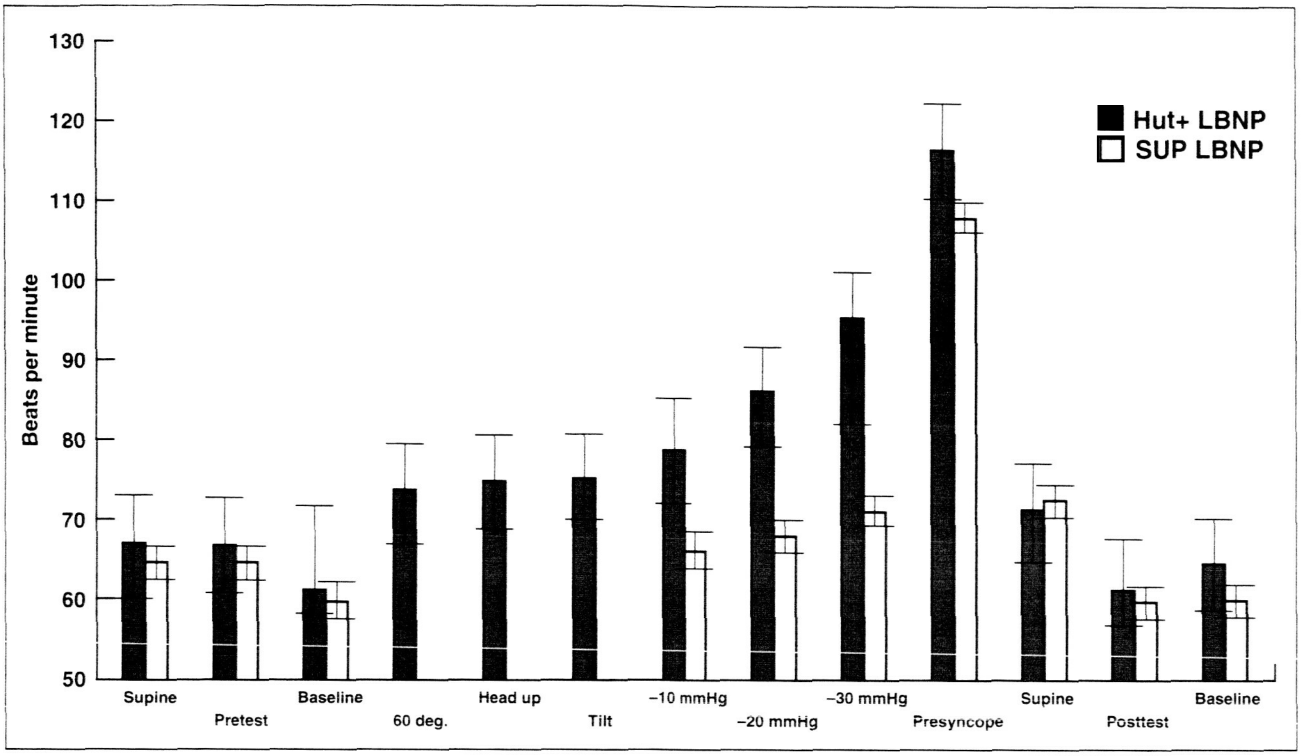

Fig. 2. Heart during supine LBNP and 60° HUT (N = 8).

baseline, minute 10 through –30 mmHg, presyncope, and during supine posttest baseline. Each bar represents a 3-minute mean.

Both hypotheses were successfully met. The HUT + LBNP can be used to reliably induce presyncope in men. However, the physiological data suggest that this device provides too strong a stimulus for testing countermeasures when used with normotensive subjects.

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Ultrasonic Measurement of Intracranial Pressure Waveforms

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Intracranial pressure (ICP) dynamics are important for understanding adjustments to altered gravity. ICP may increase during microgravity due to a fluid shift to the head. As widely observed in clinical settings, elevated ICP causes headache, nausea, and projectile vomiting, which are similar to symptoms of the space adaptation syndrome. At levels over 20 millimeters mercury, ICP may compromise cerebral circulation. However, there are no experimental results to support the hypothesis that ICP is actually altered during microgravity exposure, primarily because of the invasiveness of currently available techniques.

Ames has developed and refined an ultrasonic device that measures changes in intracranial distance noninvasively using a patented pulse phase locked loop (PPLL) technique. Although the skull is assumed to be rigid, many investigators report that the skull moves on the order of micrometers in association